Employing Net Centric Technology for a Mobile Weather Intelligence Capability

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Abstract

Weather affects personnel, military operations and weapon systems at all echelons, down to the individual soldier level. Knowing what these effects are, as well as when and where they will occur (and if they will affect the enemy to the same extent) can provide the tactical commander with critical intelligence in both the planning and execution phases of a mission. By leveraging ongoing advances in information technology related to tactical networking, communications, and computers (both hardware and software), these weather intelligence products (decision aids, alerts, map overlays, etc) can be made available to the lowest echelons. Client server computing (e.g., web services and Java remote method invocation), the Java computing environment, and wireless communications are some of the pervasive net centric technologies that will be utilized in the development and demonstration of the mobile weather intelligence capability. This capability will contribute to weather related information sharing and enhanced situational awareness at the lower echelons. A mobile computing device (Toshiba e800 personal digital assistant) is being used as the host development hardware platform.

Introduction

Weather can and does impact nearly all military operations and weapon systems. The slowdown in the advance on Baghdad in the spring of 2003 due to severe dust storms is but one example. Sometimes these impacts are minor inconveniences while other instances result in military casualties and/or losses of equipment. Numerous field manuals, technical manuals and documents[1,2,3] have been published with specific information regarding environmental impacts on operations and systems. The Army has fielded a tactical command and control system, the Integrated Meteorological System (IMETS), at brigade and above echelons to provide weather and weather effects information to tactical units. However, there currently does not exist any IMETS type functionality for the lowest echelons. Recent advances in computer hardware and software, along with net centric related information technology are now providing the means to develop and demonstrate weather intelligence (decision aids, alerts via subscription services, map overlays, data, etc) on a mobile computing device. A number of these intelligence products have been developed and demonstrated on a personal digital assistant (PDA).

Net Centric Approach

Although there are ongoing advances in the miniaturization of computer processors, storage devices, and displays necessary for the running and displaying of software applications on mobile devices, in order for these applications to be net centric, there must also be concurrent advances in information technology for the sharing of information among various devices. Web

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **JUN 2004**	2. REPORT TYPE	3. DATES COVERED **00-00-2004 to 00-00-2004**
4. TITLE AND SUBTITLE **Employing Net Centric Technology for a Mobile Weather Intelligence Capability**		5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Army Research Laboratory,Battlefield Environment Division,ATTN: AMSRL-CI-EB,White Sands Missile Range,NM,88002-5501**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR’S ACRONYM(S) 11. SPONSOR/MONITOR’S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**		
13. SUPPLEMENTARY NOTES **The original document contains color images.**		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**		**21**	

services, web browsers, the Java computing architecture, and wireless communications are some of these technologies that have been leveraged in the development of the mobile weather intelligence capability. A web service has been implemented to pass weather data from the mobile device to a surrogate IMETS server using commercial 802.11b (2.4 GHz) wireless communication protocols. Likewise, the Java remote method invocation (RMI) protocol has been used to retrieve weather information from a server over wireless comms to then be processed and displayed in Java based applications on the mobile device. A web browser on the PDA has been used in conjunction with the wireless comms to query a remote web server to provide a weather effects decision aid. This decision aid has also been made available as a standalone PDA application (i.e., no runtime connection to a server required) by hosting the relational database containing the spatial and temporal weather effects information on a 256 MB secure digital card in the mobile device. This relational database can be synchronized with the server database over a USB connection via readily available synchronization software (wireless synchronization is possible but due to the size of the database would take a significant amount of time). These and other examples of applications leveraging net centric technology to provide a mobile weather intelligence capability are examined in more detail in the following section.

Computing Environment

Mobile Device

The current mobile device on which the weather intelligence applications have been hosted is a Toshiba e800 PDA. A Compaq 3900 series PDA has also been used. The features of the Toshiba device are numerous and fairly impressive considering the size and weight:

- 400 MHz Intel® processor
- 128 MB SDRAM
- 4.0 inch 240x320 color display (480x640 with optional Resfix software)
- Integrated Wi-Fi (IEEE 802.11b) wireless communications
- Integrated Secure Digital (SD) and Type I/II Compact Flash (CF) slots
- Integrated speaker and microphone
- IR port
- 5.3” x 3.0” x 0.6” dimensions
- 6.8 ounce weight

The CF capability allows for expanded functionality, if required, such as a Global Positioning System (GPS) card, additional program/application storage, etc. Optional software that has been loaded includes the CrEme™ Java virtual machine and the 100% pure Java PointBase® relational database. Additionally, C programming language source code can be compiled specifically for the PDA processor and operating system (Microsoft® Windows® Mobile 2003) using the Microsoft® eMbedded Visual C++ environment. In this manner, both Java and C programs can be executed on the PDA. Using the Java Native Interface (JNI), C functions compiled as dynamic link libraries (dlls) can be called directly from within Java programs. The 480x640 display capability is valuable for the display of program GUIs requiring numerous inputs and/or outputs, although care must be taken in the selection of font size.

Portability Issues

Experience with the hosting of the existing weather intelligence applications from one PDA to

another has been encouraging, in that it should be straightforward to port them to current or future fielded military mobile devices (the commercial wireless comms reliance may have to be replaced with tactical wireless comms protocols such as used by the Joint Tactical Radio System). Reliance on the Java computing architecture (both the programming language and the PointBase® relational database) whenever possible has been a contributing factor in the portability ease. More than one of the Java applications has run without a hitch on multiple platforms (e.g., a Windows 2000 laptop, a Compaq and Toshiba PDA, and even a Solaris workstation) using the same compiled class files.

Mobile Weather Intelligence Applications

All of the applications described below have been developed and demonstrated on the Toshiba PDA.

Integrated Weather Effects Decision Aid (IWEDA)

IWEDA was initially developed for and fielded on the IMETS. It provides graphical and text information regarding weather impacts on hundreds of friendly and threat weapon systems over space (generally a 500x500 km area of interest) and time (48 hour forecast). Figure 1 provides an example of the temporal matrix for several weapon systems while figure 2 is a screen capture of the spatial distribution of impacts for a specific time and weapon system (in both figures, green represents no adverse impact, amber is a marginal impact and red is an unfavorable impact). The capability to compare weather impacts on both friendly and threat items is a powerful tool for both mission planning and execution. As a web browser version had been developed prior to the mobile platform effort, it was straightforward to implement this capability on the PDA using the integrated wireless communications. However, to eliminate the wireless communications dependence, a second version was developed that queries a weather effects relational database hosted on the PDA using the PointBase® relational database as discussed previously. This standalone Java application simply needs to have the effects database downloaded once and then synchronized on a regular basis (the effects database is currently updated every 12 hours). The ultimate objective is to have the effects database computed directly on the PDA (discussed later). Due to limited mapping and overlay capabilities on the PDA, only a non-dynamic overlay can currently be provided on the mobile device (the IMETS overlay is dynamic in that the user can click any point on the overlay for further information).

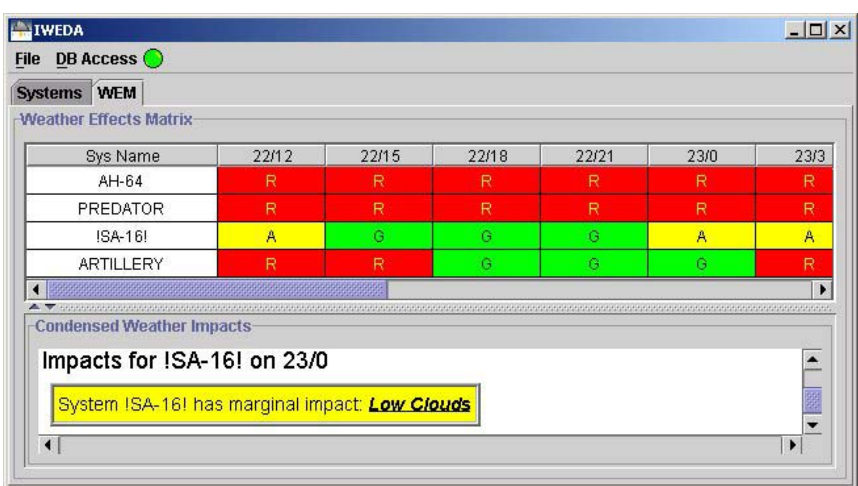

Figure 1- IWEDA Temporal Impacts

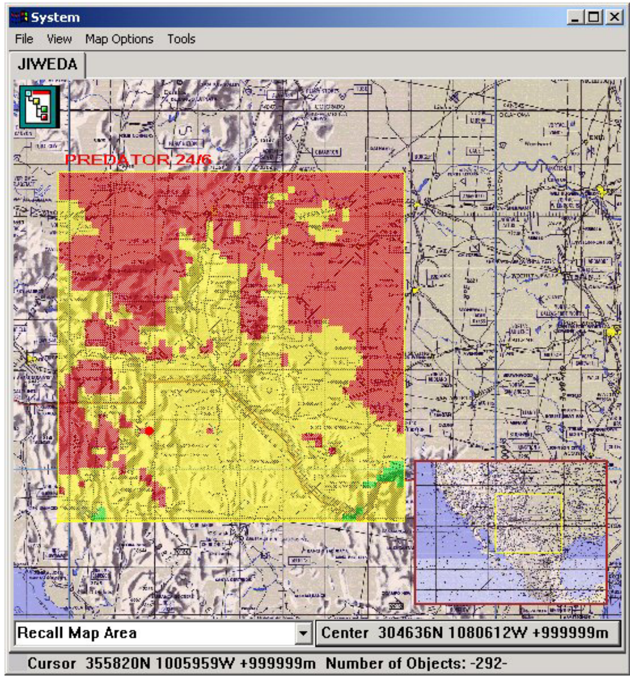

Figure 2 - IWEDA Spatial Impacts

Mobile Heat Stress

This decision aid leverages a research and development effort[4] by the US Army Research Institute for Environmental Medicine (USARIEM) at Natick, MA. Existing algorithms as provided by USARIEM were recompiled for the mobile platform after removing a dependency on a black globe bulb temperature input which would not likely be readily available on the mobile device. Instead, an algorithm already in use at the Army Research Laboratory (ARL) was incorporated to provide an estimate of the solar insolation value as a function of simple meteorological inputs[5]. A Java GUI was also developed to allow the user to enter the required inputs. If a GPS device is available on the PDA, the location information (latitude and longitude) is automatically entered for the user. The date and time inputs are likewise automatically obtained from the PDA calendar and clock. The outputs are a function of not only the meteorological, location and time inputs, but also of the user specified work rate and clothing level. Output consists of the probability of heat stress injury, the work/rest cycle, maximum work time, recommended consumption of canteens of water, and the Wet Bulb Globe Temperature. This application is completely standalone as all inputs are entered by the mobile user. Figure 3 shows the single Java GUI which contains the input fields as well as the output information.

Weather Alert Subscription

This application allows the mobile user to subscribe to one or more weather related alerts (e.g., lightning, high winds, severe cold, etc). Alert notification is made via a text message, with or without an audible alert (user specified). Java rmi servers are utilized on a laptop server and on the PDA to listen for subscriptions and notifications. The server software includes a GUI to specify the frequency that the alerts database should be queried as well as a display of the number of clients currently subscribed. The client software GUI is replicated in Figure 4. The client routine passes the alerts subscribed to as well as the client IP address to the server via the commercial 802.11b wireless comms.

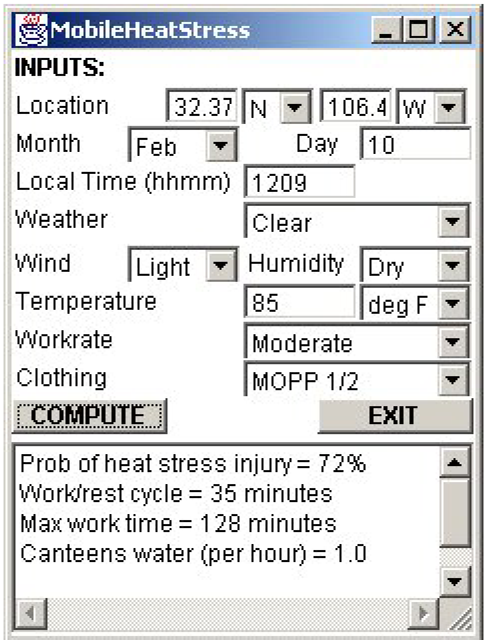

Figure 3 – Mobile Heat Stress

Figure 4 – Weather Alert

Local Observation Broadcast (LOB)

LOB provides the capability for the mobile user to enter and send a local weather observation back to a remote server. This is implemented as a web service over the 802.11b wireless communications. Potential applications of the local data on a server include being used as initialization data for a prognostic meteorological model (as currently exists on the IMETS) or as input to a CBR hazard dispersion model. It could also be used to populate a local dataset of mobile observations which, in turn, could be used to create a local gridded meteorological database (see GMDB section below). This gridded database could then be utilized as input for the PDA decision aids and alerts or in the display of weather conditions (e.g., streamlines or vectors of wind velocity, contours of air temperature, etc) via map overlays. A simple Java GUI allows input of several meteorological parameters to include wind velocity, temperature, cloud conditions, and visibility (the list can be modified as necessary).

Mobile Acoustic Detection

Probability of detection of a user specified acoustic target (e.g., tank, aircraft, etc) by a specified sensor (e.g., microphone, human, etc) is provided via a Java remote procedure call on a server. Acoustic propagation tables are computed a priori on the server as a function of existing or forecast weather and terrain conditions. This application is currently a prototype as there are only a limited number of targets and listening devices. There is also only a single static acoustic propagation table. Future enhancements could involve the dynamic creation of the propagation tables and an automatic computation (and display via graphics and text) of the probability of detection for target/sensor azimuths covering 360 degrees (as opposed to a single user specified azimuth).

Gridded Meteorological Database (GMDB)

As discussed briefly in the LOB section, an ultimate objective is to compute and store a gridded meteorological database directly on the PDA. This would, to a large extent, eliminate the requirement for wireless communications between the mobile device and a remote server, as the local GMDB could be queried as the source of meteorological inputs for the existing and planned mobile applications and could eventually be used as the input source for the computation and derivation of weather effects tables (e.g., acoustic propagation) and databases (the IWEDA effects database). Limited comms to a remote server would still be required to retrieve additional data as required for the initialization of the software to create the GMDB (e.g., a limited number of prognostic data gridpoints from a forecast weather model that includes upper atmospheric data that could not be directly measured or deduced by the mobile user). Once the remote data is obtained and supplemented with local observations, mathematical objective analysis routines can be run on the mobile device to compute and store the gridded meteorological information for analysis and very short forecast times. Initial coding and benchmarking has been done along these lines by creating uniform gridded fields on the PDA with simulated local surface weather observation data. Computation of 100 gridpoints for a single parameter (e.g., air temperature) takes less than 5 seconds on the Toshiba PDA (includes the writing of the output grid as a text file). These fields are only for surface parameters, however (i.e., 2 dimensional). The full capability as discussed in this section is likely some years off due to the relatively limited computing power of the mobile device.

Future Efforts

The development and demonstration of the technology as outlined above should be viewed as the first step in providing a truly net centric weather intelligence capability. Additional development and enhancement of the mobile weather intelligence suite of products is required to enable collaboration among independent applications. For example, the Java objects that form the core of the weather intelligence applications should be made available as web services such that decision aids or applications that do not presently include weather effects have a means of incorporating them independently. JavaSpaces™ Technology can be used in the implementation of a network accessible, shared memory repository to facilitate the reading, taking and writing of these objects via loosely coupled processes[6]. Ultimately, the effects of the weather could be automatically included in mission planning and execution via dynamic background agents that do not require any human intervention. These agents would be able to determine and prioritize ongoing or planned military missions and then query the JavaSpaces to retrieve pertinent information to synthesize and present an integrated picture of all of the elements potentially affecting mission completion. Note that this information would need to include sources other than just weather, e.g., logistics, terrain, enemy, etc. This approach could be used at all echelons.

Summary

The advent of capable mobile computing devices along with net centric related technologies has allowed for the development of a number of weather intelligence applications on a Toshiba e800 PDA. These applications have been shown to be highly portable, and as such, would seem to be likely candidates for inclusion in tactical portable computing devices (either existing or planned) to fill a niche with respect to sharing and enhanced situational awareness of weather and weather effects. Future advances in mobile information technology are inevitable, thus even more sophisticated and able applications can be envisioned in the near future.

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ACKNOWLEDGEMENTS

- Mario Torres
- David Marlin
- Barbara Sauter
- USARIEM*

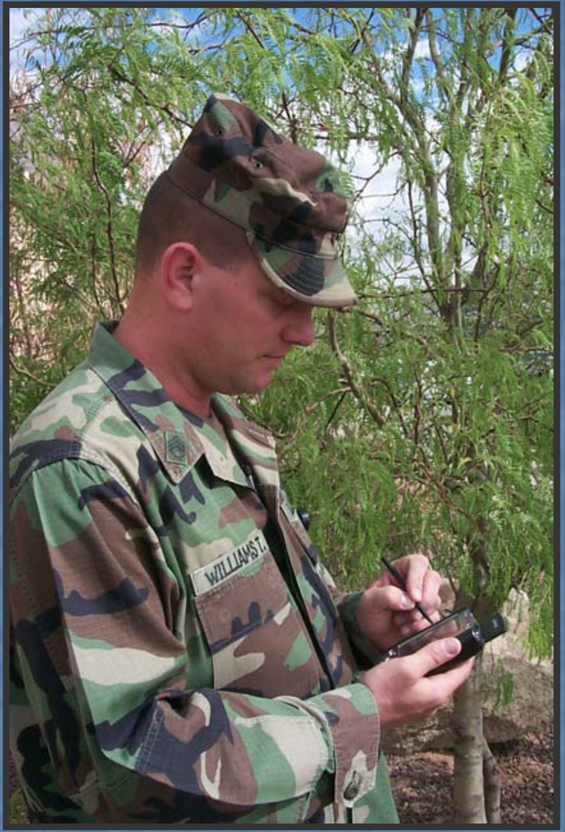
*US Army Research Institute of Environmental Medicine, Natick, MA

BACKGROUND

The environment can adversely affect weapon systems and military operations at all echelons. A priori and near real-time knowledge of these effects (both over time and space) can assist the Commander and Soldier in both the planning and execution phases of missions.

OBJECTIVE

Develop weather related Actionable Intelligence (e.g., decision aids, alerts, situational awareness, etc) to enable rapid visualization and understanding of critical information. Provide this Intelligence via net centric means* on a mobile device to empower lower echelon users.



*Examples of net centric technologies include distributed computing (e.g., web services and Java remote method invocation), wireless and mobile computing, network protocols and shared dataspaces

APPROACH

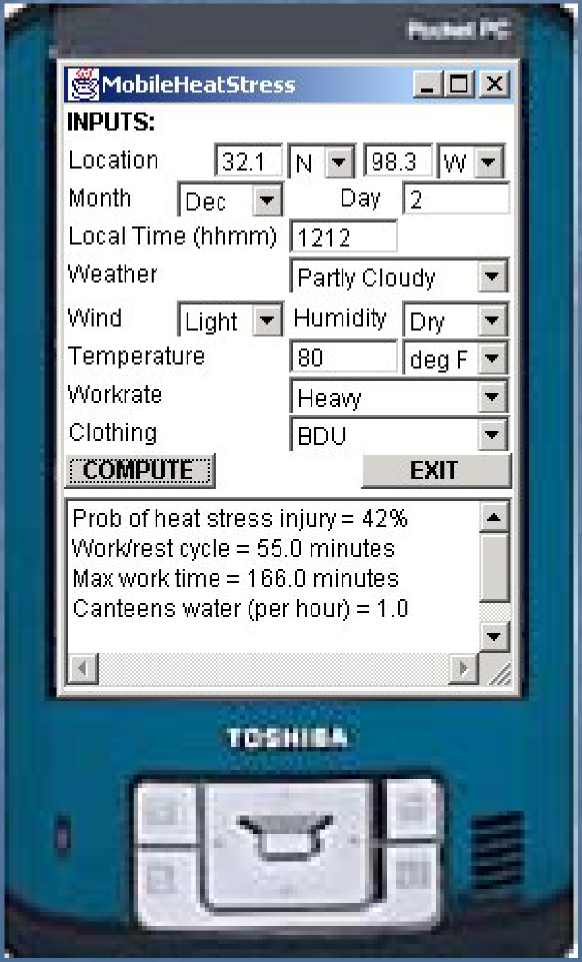
- Continually leverage rapid advances in hardware technology to host applications on a highly portable mobile computing device

- Develop applications using emerging & existing software standards (e.g., Web services, XML, Java) for portability and rapid transition of the technology to the Warfighter

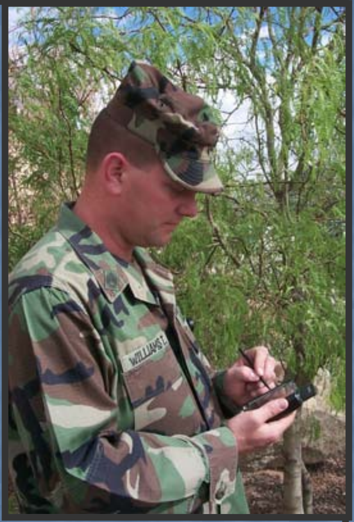
- Develop standalone applications for the mobile device where possible to eliminate requirement for a remote server

PROTOTYPE MOBILE PLATFORM

Toshiba e800 personal digital assistant (PDA)



- 5.3” x 3.0” x 0.6”
- Color display
- 128 MB SDRAM

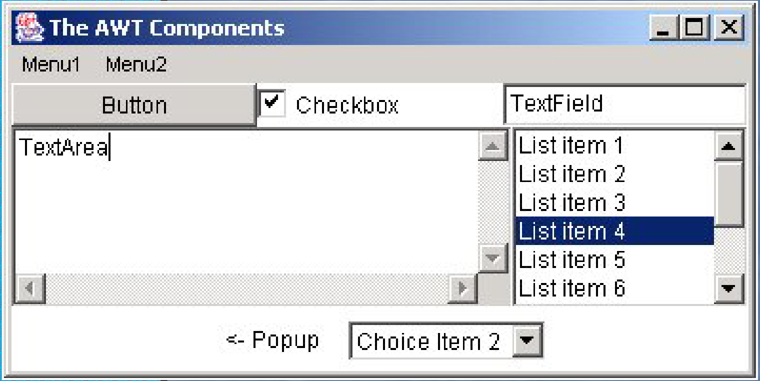


- 6.8 ounces
- 400 MHz processor
- 240x320/480x640 resolution
- Embedded microphone/speaker
- Integrated Wi-Fi (802.11b)
- Integrated secure digital slot
- Integrated Compact Flash slot

SOFTWARE ENVIRONMENT

Java for most application coding

- Fairly robust programming and graphical user interface capabilities
- Very portable code (tested under Win2000, PocketPC OS and Solaris Unix with no recompilation)
- Small footprint binaries (10's of Kb)



Java remote method invocation for client/server

- Allows PDA to make remote queries to a relational database server over wireless comms (802.11)

Relational database software on secure digital card

- Applications can query local DB if wireless comms unavailable

INTEGRATED WEATHER EFFECTS DECISION AID (IWEDA)

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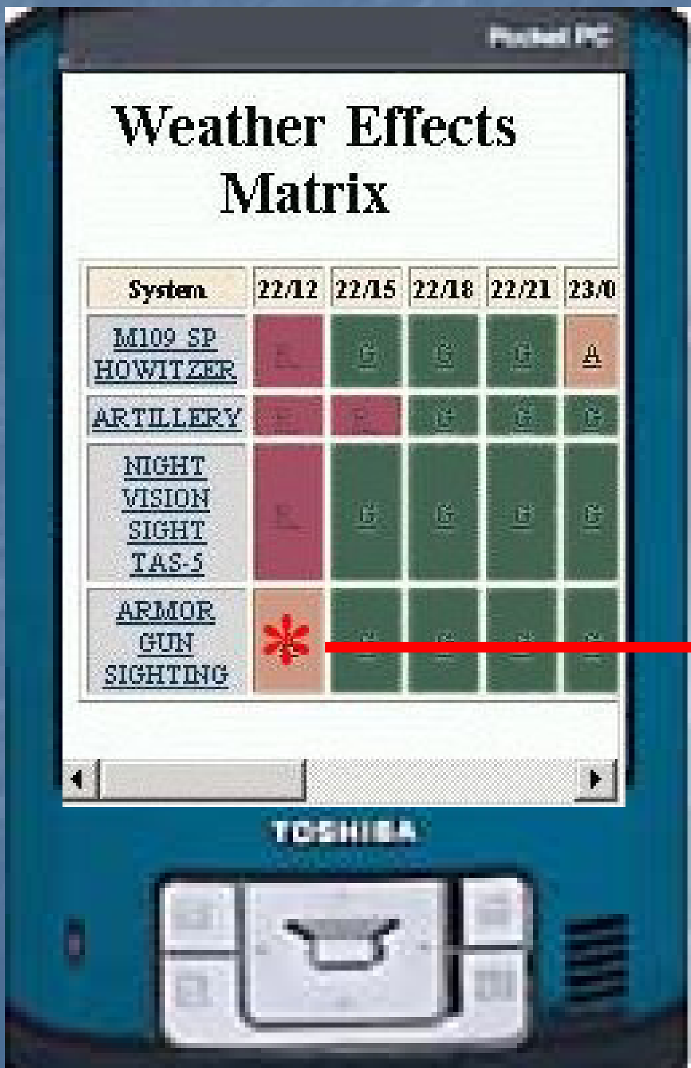

- Provides critical environmental effects information
- Inventory of 300+ weapon systems and operations (numerous foreign)
- Color coded impacts
- Static map overlay capability
- Remote and local server versions
- Matrix cell tap retrieves the basic weather impacts:

Condensed Impacts

System name: **ARMOR GUN SIGHTING**
Forecast period: **22/12**

System ARMOR GUN SIGHTING has marginal impact: ***Low Visibility***

WEATHER ALERT SUBSCRIPTION

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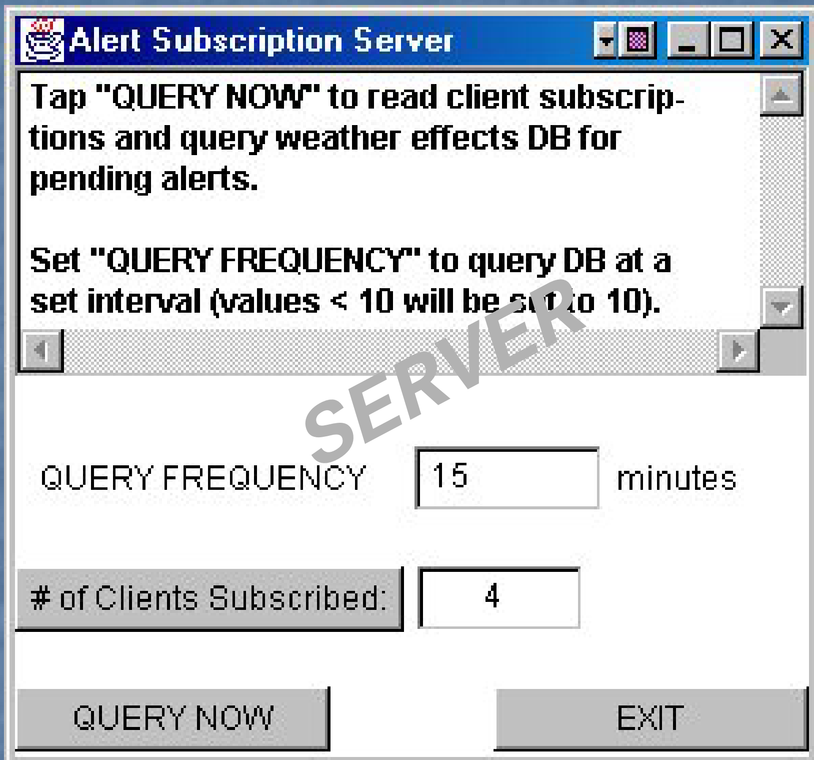

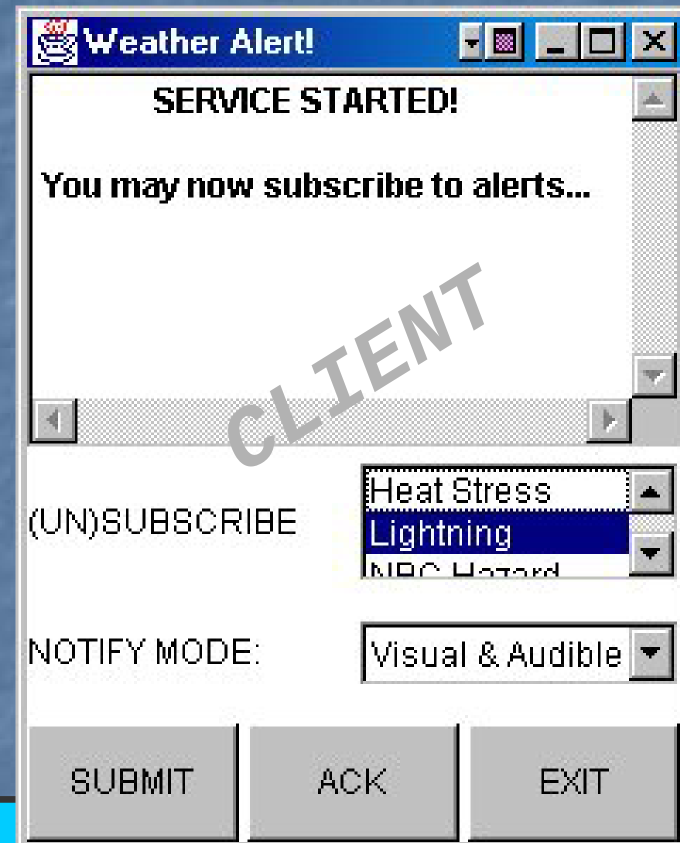

- Two alert modes (visual/visual&audible)
- Several alert subscription choices
- Integrated w/GPS capability to automatically set geographic location (spatially dependent alerts database)
- Requires wireless comms back to a remote server

MOBILE HEAT STRESS

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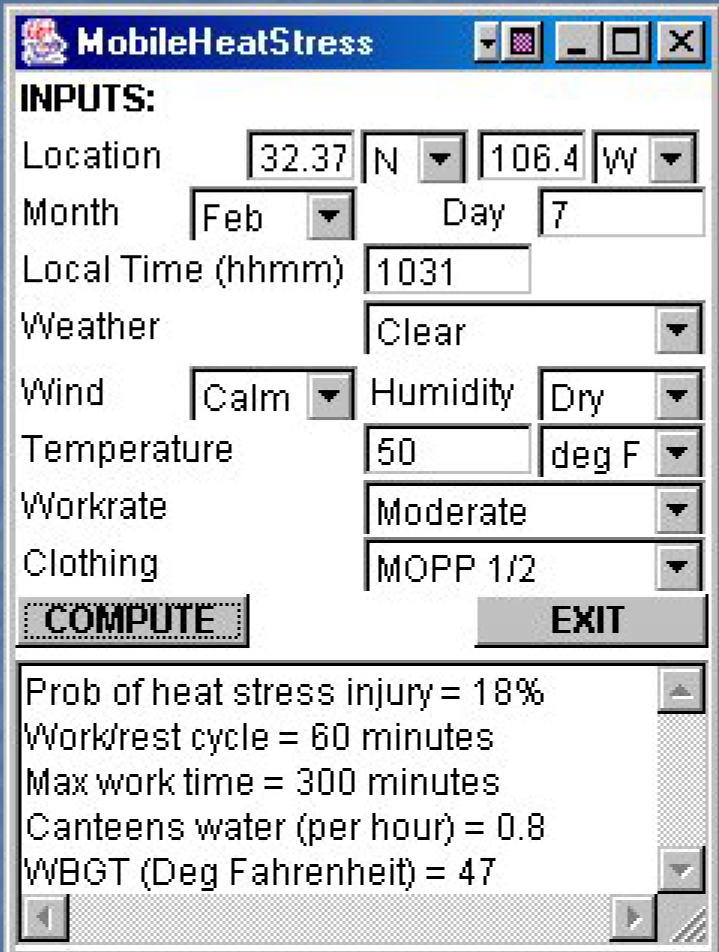

- Provides critical heat stress parameters based solely on local input of data
- Underlying physics based algorithms from USARIEM
- Current date/time and location are automatically set using Java utilities and GPS output (if available)
- Java GUI; USARIEM algorithms and insolation calculation in a C dll accessed via Java Native Interface
- Input is error trapped for valid entries

SPOT WEATHER REPORT

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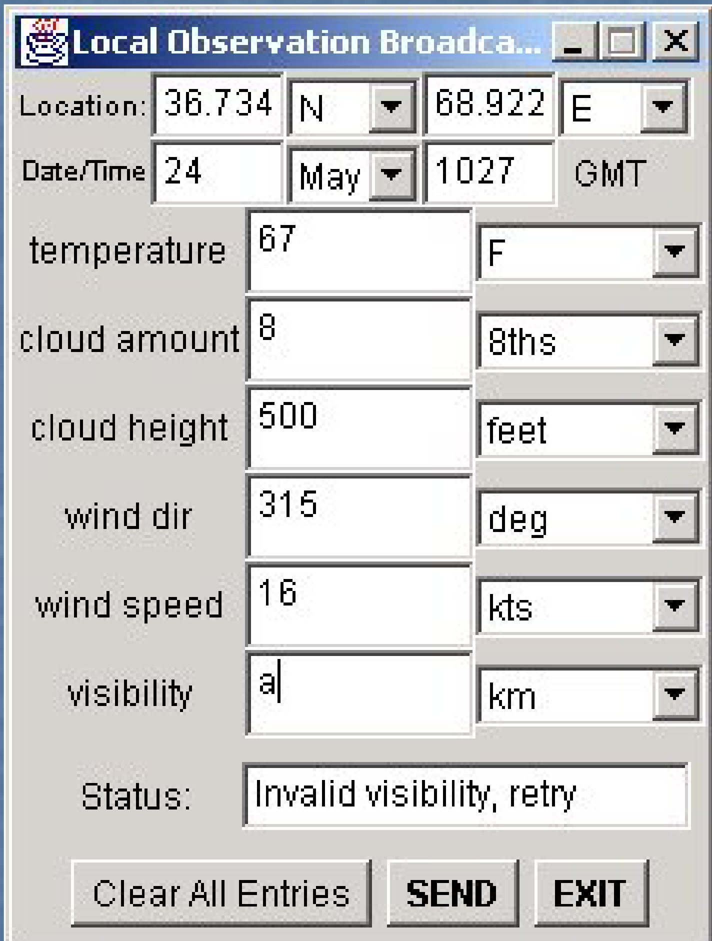
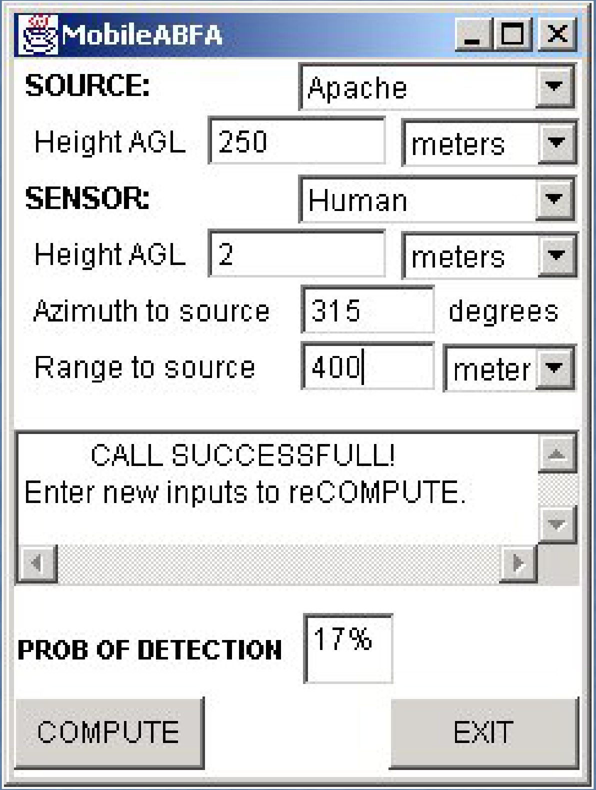


- **Allows entry and transmission of local weather observation to remote server**
- **Potential uses: initialization of a prognostic or diagnostic high resolution weather model; in a CBR diffusion model; etc.**
- **Current date/time and location are automatically set using Java utilities and GPS output**
- **As with other mobile apps, input is error trapped for valid inputs**

PROTOTYPE APPLICATIONS

Mobile Acoustic Propagation Decision Aid:

Provides probability of detection of an acoustic source given a sensor and the range & azimuth between them



High Resolution Objective Analysis:

- Real time 2-D objective analysis of sparse meteorological observations (e.g., wind speed, temperature, etc)
- Provides a regularly spaced high resolution analysis field
- Output potentially can be used as input for various other applications at locations where direct measurements are not available

LEGACY APPLICATIONS

Two Pascal applications running under DOS emulator:

- 3D Chemical Hazard – Provides prediction of the horizontal and vertical extents of chemical vapor hazard to low flying aviators

- Night Vision Goggles – Provides guidance (text and graphics) on favorable times of NVG use as a function of predicted ambient illumination.

FUTURE EFFORTS

- High resolution 3-D meteorological analysis capability
- Interactive mapping capability
- Collaborative software agents
- Investigation of JavaSpaces* technology for implementation of distributed applications and data
- Additional decision aids/applications
- Partner with an ongoing program or participate in an exercise/demonstration to evaluate utility of products

*A JavaSpace is a network accessible, shared memory repository for reading, taking and writing of objects via loosely coupled processes